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Predicting naval aviator attrition using economic data

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THESIS

PREDICTING NAVAL AVIATOR ATTRITION USING ECONOMIC DATA

by

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March, 1996

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PREDICTING NAVAL AVIATOR ATTRITION USING ECONOMIC DATA

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ABSTRACT

Understanding and accurately predicting attrition is vital to correctly managing the retention of naval aviators. This thesis investigates the ability of models incorporating a number of economic measures to predict naval aviator attrition rates. Using data from 1978 to 1990, this study examined a wide range of potential economic explanatory variables and their effects on naval aviator attrition rates. The naval aviator data set was grouped into six populations, separated by aviation community (helicopter, jet and propeller) and by years of service (5-8 and 9-12). Three separate linear regression models for each of the aviator groups were developed, and their predictive ability evaluated. The study found that: no single model was best at predicting attrition rates for all groups; simple models using one or two variables performed better than complex, multivariate models; the most useful predictor variable was the national unemployment rate; attrition rates with the highest levels and variability were in the jet and propeller pilot groups with five to eight years of service, and the most significant models, able to outperform a naive prediction, were found for these groups.

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I. INTRODUCTION

During the recent era of military downsizing between the years of 1991 and 1995, naval aviator retention issues were not at the forefront. After all, this was a period which saw Involuntary Reduction in Active Duty (IRAD), Voluntary Separation Incentive (VSI), Special Separation Bonus (SSB) and early retirement incentive programs used to reach new end-strength targets. However, the Navy is now approaching its new manning level targets, which means that managing the retention of qualified naval aviators will be more important than ever. With a smaller corps of pilots, the effects of large or unexpected fluctuations in retention (like those historically seen), may make the retention issue more challenging than ever before.

The United States Navy invests a significant amount of time and money to train a naval aviator. In fact, at a marginal cost of between $250,000 and $750,000, it is among the most costly training provided by the Department of the Navy, representing one of the biggest investments in human capital. The average time to successfully train a new pilot, from flight school to fleet squadron, averages almost two years (depending on aircraft). Thus, the value of retention is both financial, in terms of return on investment, and logistic, in terms of managing a steady flow of talented pilots. While some attrition of Navy pilots is expected and desired to maintain the downstream billet structure, en masse, cyclic resignations in the past have led to severe pilot shortages.

To help mitigate periods of unacceptable pilot attrition during the late 1970s and again in the late 1980s, the Navy employed Aviation Officer Continuation Pay (AOCP) and Aviation Continuation Pay (ACP) respectively. These were bonus plans aimed at reducing the gap between downstream billet structure requirements and an established retention rate below that necessary to meet those requirements. The ACOL (Annualized Cost of Leaving) model was used to determine the marginal cost (bonus amount) per retention percentage increase required to meet pilot shortfalls in each mission community (Cymrot 1989). Unfortunately, gross shortages in certain year groups occurred before these programs were implemented, while surpluses in other year groups occurred in the early 1990s, when bonuses were still available.

Timing is critical for these bonus plans and other retention tools to work efficiently. Insufficient lead time can result in reacting too late to retention crises. Additionally, crisis reactive personnel policies can lead to irregular promotion rates, inconsistent personnel policy and year-group shortages and surpluses, all of which have adverse effects on long term manpower planning. Correctly managing naval aviator retention is vital to ensuring a talented and motivated pilot base. With the proper tools and authority, pro-active personnel policies can lead to effective and efficient pilot retention management. This hinges on the ability to understand and accurately predict officer attrition with sufficient lead time to act.

A. BACKGROUND

By far, the highest degree of voluntary separation is found between six and twelve years of service (YOS)[1]. This is perfectly understandable, given the context of a normal career progression. Following primary and advanced aviation training, prospective pilots are

[1]The Aviation Career Improvement Act of 1989 extended minimum service requirements to seven years, (nine years for jet pilots). Its effects on retention are still to be seen starting in 1996.

designated as a naval aviator and incur a Minimum Service Requirement (MSR). Next comes Fleet Replenishment Squadron (FRS) training, where pilots learn to fly their assigned aircraft. During the first sea tour, the member increasingly gains knowledge and flight experience performing a mission specialty, and during the following shore tour, often serves as an instructor pilot. Typically, after completion of the shore tour, the aviator completes the MSR and the initial obligation to the Navy expires. It is between this point and the twelfth year of service that Navy pilots have the highest probability of resigning; when the naval aviator is young, skilled, employable, and not under a commitment or personally invested in a military retirement (Figure 1). Managing the retention behavior of pilots in this career stage is pivotal to establishing the career (downstream) billet structure and accession targets.

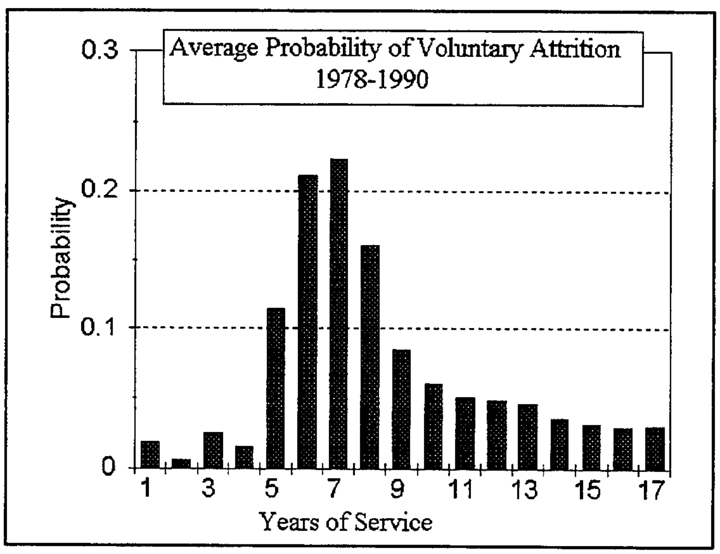

Figure 1. Attrition Rates 1978-1990. (Source: Turner)

Undoubtedly, an officer's decision to leave the Navy is a complex one, influenced by a wide variety of factors; demographic characteristics, family and marital status, economic opportunities and attitude towards a military lifestyle. But the list of factors greatly diminishes when we focus on the determinants of the vicissitudes in the attrition rates. For example, marital status and family separation may be major factors influencing attrition, but it is unlikely that they have fluctuated greatly and caused the wide fluctuations in attrition rates observed in Figure 2. On the other hand, economic conditions and civilian employment opportunities have fluctuated, indeed they are by nature cyclic.

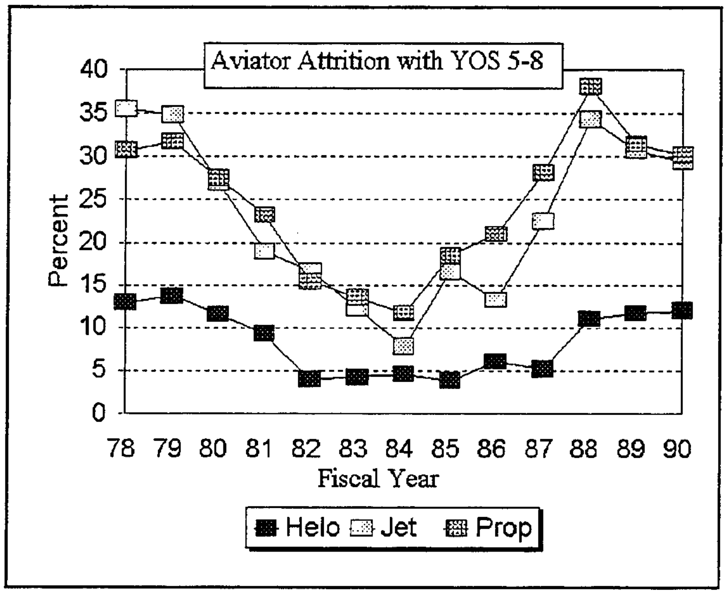

Figure 2. Attrition Rates by Community. (Turner)

B. OBJECTIVE

The purpose of this thesis is to examine and evaluate observable, economic conditions which can explain or predict attrition behavior of naval aviators. To accomplish this, historical economic and retention data need to be analyzed to identify any trends and patterns that may exist. The literature documents fairly well a positive relationship between Navy pilot attrition and the state of the economy. Economic indicators, airline hiring, and general employment opportunities often change in consort, and consequently impact retention.

This study attempts to develop a model using regression analyses that will accurately predict Navy pilot attrition in a manner timely enough to use policy tools effectively.

C. RESEARCH QUESTIONS

1. Primary research question:

Can a model be built, using economic indicators and other information available to planners, to accurately predict naval aviator attrition.?

2. Secondary research question:

What effects do various economic measures have on naval aviator attrition rates?

D. SCOPE AND LIMITATIONS

This thesis will examine attrition behavior of naval aviators in each community during the period between 1978 and 1990. This time period was deliberately selected for several reasons. Examining determinants after 1990 may not be representative of normal attrition behavior, given the post-cold-war drawdown environment and subsequent force reduction policies. Data examined prior to 1978 might be skewed by Vietnam war era issues. This period (post Vietnam through the Reagan build up years) also saw a steady improvement in the status of a military career in terms of prestige, career optimism and pay, while the economy and airline industry experienced the extremes of a full business cycle: the recession of the early 1980's and the boom of the later 1980's.

This study focuses on economic environmental factors external to the Navy, and examines their effects on attrition rates. This is a macro view of the attrition equation. The focus of this study is *not* to determine all factors which correlate with retention, or to necessarily explain why *individuals* stay or leave the Navy. To hold constant for individual factors, this study assumes that when pilot inventories are aggregated, individual factors average out, effectively making the populations relatively homogenous in their predisposed behavior.

All three aviation communities, helicopter, propeller and jet, will be examined in this study. However, the focus group will be those aviators past their MSR and between five and twelve years of service. This is where the bulk of both attrition and ambiguity exist, and where a predictive instrument can have the most value.

E. ORGANIZATION

Following this introduction, Chapter II reviews previous research relevant to pilot attrition issues. Chapter III introduces the methodology and discusses the process of variable development. Data analysis, statistical results, model specification and model validation are presented in Chapter IV. Finally , Chapter V concludes with the findings of this study and makes recommendations for future research.

II. LITERATURE REVIEW

Several studies, from several different perspectives, have looked at the complex issues of Navy pilot retention. Some affirm a connection between external economic environmental factors and Navy pilot attrition, while others offer analytical techniques and motivating factors.

A. ATTRITION MOTIVATORS

1. R. Gordon Lawry II, "A Statistical Analysis of the Effects of Flight Time on Naval Aviator Retention", Thesis, Naval Postgraduate School, September 1993

In his study, Lawry posed the following research questions:

- Is there a quantifiable and statistically significant relationship between aviator flight-time and first-tour retention?
- What is the magnitude of the effect, if any?
- Does the existence and magnitude of this relationship differ among aviation communities?

Here he examined the relationship between the number of flight hours flown by naval aviators and the possible effects on their decision to continue in the Navy, following the expiration of their first service obligation.

Flight hour data and demographic data came from the Naval Safety Center (linked by social security numbers) and Defense Manpower Data Center (DMDC) Officer Master File and Loss files, respectively. Additional data included airline industry wage and hiring data obtained from Future Airline Professionals of America (FAPA) and unemployment data from the U.S. Commerce Department's Bureau of Labor and Statistics.

The hypothesized results were based on the premise that the total utility retention function must also incorporate personal, non-pecuniary factors such as an aviator's joy of flying. Thus, higher retention behavior was expected for aviators whose personal experience included relatively higher flight-time.

In separate binomial logit multivariate models for each aviation community (jet, propeller and helicopter), the dependent variable was set as a probability of retention. The independent variables included individual's flight-time, marital status, number of children, race, starting airline salary and number of pilots hired by major airlines.

The study concluded that the flight-time variable was significant in propeller and jet communities only, but contrary to expectation in that higher flight-time led to higher attrition (reduced retention). Other variables determined to have significance were:

- airline pilot hiring which had a negative effect on retention for all three communities.
- civilian pay (airline salary) which proved to have a negative effect on retention in all three aviation communities.
- marital status which showed a positive relationship between being married and retention.
- child dependents which indicated that pilots with children were more likely to separate from the navy.
- race which indicated that non-whites were more likely to remain in the military.

Although the study effectively dismissed the perception that increased retention could be found by increasing flight-time, it provided important confirmation to manpower planners of the connection between basic economic factors and retention.

2. David A. Kriegel, "An Examination and Comparison of Airline and Navy Pilot Career Earnings", Thesis, Naval Postgraduate School, March 1986

This thesis compared lifetime incomes of Navy and major airline pilots. The author used regression analysis of actual 1983 pilot wages to predict average wages as a function of pilot seniority. The analysis adjusted for future wage changes and used them to forecast thirty-year pilot earnings in two distinct career paths. One path assumption was that the pilot remains in the Navy, retires at age forty-two, then flies for an airline, retiring at age sixty. The alternative path assumption has the pilot flying for an airline immediately following MSR and retiring at age sixty. The average military benefit of tax-free income and allowances were computed. Three Navy salaries were compared against weighted-average airline salary. Comparisons were made of earnings and retirement benefits, using a discount rate of five percent.

The findings indicated that a Navy pilot will maximize his income by remaining in the military until retirement, and then flying with an airline. The author determined that (with the then-recent increases in pay, bonuses and benefits) the present value of Navy pay exceeded airline earnings by three to six percent. The study also noted a trend of decreasing benefits for airline pilots in the wake of industry deregulation and predicted that if airline wages continue to decrease, while Navy pay remains constant or increases, the comparison will shift further towards a Navy career.

This study was extremely thorough in capturing all pecuniary variables in both Navy and airline compensation. One fundamental weakness in the study was in the validity of the premise of the alternative career path. The probability of successfully retiring from the Navy and then flying for an airline at age forty-two is exceptionally low, according to the study's own data. Age of hire data indicated an extremely low probability of hire for a pilot of retirement age. Also, age forty-two would be the minimum age of most retirees with many pilots retiring at older ages, making the probability of this alternative even more remote. This reality redefines the MSR stay/leave decision from a sophisticated present value model of future career earnings, to a personal overall career decision of either joining the airlines when the opportunity presents itself, or serving out a military career and then doing something else (other than flying for the airlines).

Another consideration is the assumption that the naval aviator continues to promote, which is required to reach the rank of Commander (O-5) and to be eligible for twenty-year retirement. In fact, approximately forty percent of Lieutenant Commanders (O-4) may fail to promote (depending upon the promotion rate approved by Congress).

Among the recommendations given in this study was one to educate aviators about the "true" future value of their career earnings as a way of improving retention. But retention data shows that despite a steady annual increase of approximately 2.5 percent in pay and allowances from 1984 to 1988, the pilot attrition rate in the jet and prop communities (YOS 5 to 8) rose from 7 to 34 percent and from 11 to 38 percent respectively.

B. ECONOMICS AND PILOT ATTRITION

1. Samuel D Kleinman and CDR Charles Zuhoski, "Navy Pilot Attrition: Determinants and Economic Remedies", Center for Naval Analyses, February 1980

In 1978, the Navy's Bureau of Personnel requested the Center for Naval Analyses (CNA) conduct a study to determine the effects and costs of an aviation bonus. CNA broadened the study to examine the effects and costs of Aviation Continuation Incentive Pay (ACIP) and to research other factors that may affect pilot retention. The study examined the effect of compensation on pilot attrition for the period FY 1963 to FY 1978. Officers commissioned from the United States Naval Academy, Naval Reserve Officer Training Corps (ROTC), and Aviation Officer Candidate School (AOCS), who completed their initial obligation, were examined separately in the analysis.

The regression analyses set attrition rates from FY 1963 to FY 1978 as the dependent variables. Two attrition rates were computed for each year-source-tenure class. The first was the unconditional attrition rate, where the initial accession class is the base; the second is the conditional attrition rate, where the number of officers at the beginning of the year is the base. The number leaving the pilot designation during the year was in the numerator in each case. Problems were encountered obtaining continuation rates for some years in certain sub-groups. Attrition rates were lagged six months from the calendar year's employment variables to account for the military's six month notification requirement.

Explanatory variables included changes in airline employment, military pay, airline pay, change in navy requirements, casualty rates and flight hours. Airline employment was estimated by converting airline industry hiring from Employment and Earnings reports from the Bureau of Labor Statistics, by assuming pilots account for ten percent of new hires. Airline wages were determined statistically using benchmark salaries obtained from Airline Professional of America (ALPA).

The focus of the study was not to predict retention, but to determine elasticities of retention rates with respect to pay to help make informed policy decisions. A logit function was specified and appropriately weighted to remove heteroscedasticity, and zero values were set equal to .001.

The authors noted that Vietnam casualty rates rose and declined at the same time as changes in airline employment, making it difficult to identify the individual effects of each on retention.

Among the principal findings of the study:

- Pilot retention decreased when commercial airline employment increased.
- Among Naval Aviators just completing their minimum service requirement (MSR), retention was directly related to the differences between military and commercial pilot salaries.
- Changes in the Navy's requirements for pilots (demand in itself) had little influence on the attrition of pilots in the period examined.
- The casualty rate during the Vietnam war had a negative effect on the retention rate of Navy pilots.

- The number of pilot flight hours flown in the Navy was unrelated to the retention of pilots in the period examined.

- Overall economic opportunities in the civilian sector, as measured by changes in employment in the private sector and in the median income of male college graduates, were not related to the retention of pilots over the sample period.

The study also examined the effects of alternative pay incentives. They concluded that a bonus award vice an increase in ACIP would be more cost effective.

2. Donald J. Cymrot, "Implementation of the Aviation Continuation Pay (ACP) Program", Center for Naval Analyses, April 1989.

This research was conducted to support the Navy in designing an implementation plan for the Aviation Continuation Pay (ACP) program. The ACP program addressed the critical shortages seen when too many aviators left the Navy between the time they completed their active duty service obligation and the time they serve in more senior, department head billets (at about eleven years of service).

The approach CNA used to measure the differences in military and civilian employment utility was the Annualized Cost of Leaving (ACOL) model. The theory behind this model is that an individual will decide on staying in the military or leaving for civilian employment based on perceived future costs and benefits of each alternative. For aviator retention analysis, the model was defined by three main factors (with airline industry data used as proxy for competing civilian employment):

- Relative pay; the differences between the present value of the actual and projected civilian (airline) and military pay.

- Civilian employment demand; the hiring rates of the major airlines.

- Unemployment rates; the condition of the job market.

Previous continuation rates for specific aircraft communities were used as baseline figures. Military pay tables were used to derive military pilot projected pay through the twentieth year of service. The equivalent civilian pilot pay used was average annual pilot pay, determined from survey data obtained from the Airline Pilots Association (ALPA), a pilots' labor union representing several airlines. An earnings equation was estimated, using weighted least squares, and a predicted earnings profile was developed.

The findings from the study primarily included the responsiveness of retention to pay, for various groups of aviators. This ultimately led to a policy of varying amounts of bonus pay, determined by the required retention and the responsiveness of that community to monetary incentives. Interestingly, the magnitude of the effects of the explanatory variables was small. Relative pay was found to be a very significant factor for helicopter pilots (who generally do not find employment in airlines) while propeller and jet pilots' reaction to relative pay were insignificant. Civilian airline hiring affected retention in all communities; most significantly in propeller pilots and least significantly in helicopter pilots. Unemployment was a significant factor in all aviation communities. Helicopter pilots were the most sensitive with propeller and jet pilots less so.

The focus of the study was more towards cost and effectiveness of a proposed ACP program, and less on explaining or predicting retention. It effectively tried to predict the amount of money required to increase the probability of retention in a population of undecided aviators.

Certainly, narrowing the gap between military pay and airline pay (using a bonus) is an effective retention tool. The finding that pilot attrition is sensitive to *changes* in the airline-military pay gap may be worthy of further study. Navy pilots must submit resignation requests to document their availability before they even apply for an airline position. There is tremendous uncertainty in the selection process employed by major airlines, which usually leads pilots to accept the first position available and subsequently stay with that carrier. When these structural considerations are coupled with the fact that there is significant disparity in the salary schedules from carrier to carrier[2], it seems questionable that changes in attrition rates are influenced by changes in the difference between airline pay and military pay, both of which change incrementally at best. A simpler explanation may be that airline pilots are well-paid, and that any effort to improve military compensation will reduce attrition.

C. DETERMINING RETENTION RATES

1. Donald J. Cymrot, Patricia E. Byrnes, Joseph T. Schertler, "Determining Continuation Rates for Pilots from the Officer Master File", Center for Naval Analyses, June 1988.

The Officer Master File (OMF) is the primary source used to measure continuation rates of officers in the Navy. This research examined how the definition of the continuation rate for Naval officers is implemented using data for the OMF. Continuation rates are measured for a cohort of officers defined by their qualifications and year group. Several

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[2] In 1995, sixth-year monthly pay at United Airlines and America West Airlines was \$89,300 and \$50,486, respectively. (Compass. Future Airline Professionals Association, 1995)

conceptual and data problems were addressed in defining "continuation rate" and various inflows and outflows for specific cohorts.

The continuation rate for a cohort of pilots is defined as the number of pilots in the cohort at the beginning of a period divided by the number of officers in that cohort at the end of the period. The continuation rate in year t (C_t) can be defined as

$$C_t = \frac{A_t}{N}$$

where N is the starting inventory and A_t is the number officers on active duty at time t. The difference between A_t and N is supposed to be attributed to attrition. The two major sources of attrition for pilots are lateral transfers (officers who change to non-pilot designators) and officers who leave the navy. The paper also points out problems with tracking outflows and inflows which it characterizes as "turbulence". Elements which contribute to this turbulence are *Year group ins* (entry into the year group from another), *lateral ins* (transfer of a non-aviator to an aviator designator), *accessions* (those new to active duty), *Year group outs* and *lateral outs*.

The analysis revealed that turbulence can cause attrition to be overstated when it is based on gross continuation rates (GCR) obtained by matching beginning and ending inventories, because of excluded inflows. The authors conclude that, when continuation is used as an indicator of total inventory, inflows should be included. Thus, net continuation rates (NCR), obtained by comparing the beginning inventory of one year to the beginning inventory of the next, is a more accurate measure of continuation. However, when the continuation rate is needed to measure the response of attrition to policy changes, tracking initial inventories is a better measure of continuation.

2. Russell S. Turner, "The Impact of the Military Drawdown on USN Aviator Retention Rates", Thesis, Naval Postgraduate School, March, 1995.

The objective of this study was two fold; to construct a unique analytical data base containing calculated continuation rates of Naval Flight Officers (NFO) and Naval aviators in each community (propeller, helicopter and jet), then to examine the effects of several military policies on retention of these Naval officers.

This thesis used grouped data defined by year of commission, fiscal year, and aviator type. The analysis quantified the relationship between various downsizing policies and cohort continuation rates while controlling for the effects of time-since-MSR and civilian unemployment.

a. Creating the retention database

The database was created from the Officer Master File (OMF) maintained by the Defense Manpower Data Center (DMDC). Fields used for filtering records included commissioning date, officer designator, loss code, additional qualifying designators (AQDs) and minimum service requirement (MSR). These filters ensured that only aviators and flight officers who were eligible to resign voluntarily were extracted from the data history tapes. Separate files were created for each of fifteen different fiscal years from 1977 to 1993 which contained Naval aviators from year groups 1960 through 1993. Cohort continuation rates were calculated by taking the cohort ending inventory and dividing it by the cohort beginning inventory. Continuation rates were calculated for each fiscal year by year group and community.

b. Regression results

The continuation rates were set as the dependent variable for separate ordinary least squares (OLS) regression models for each community. The following explanatory variables yielded the following effects:

- Aviation Continuation Pay (ACP), was statistically significant and showed a direct relationship between the bonus availability and retention with all models, with the exception of jet pilots.

- Voluntary Separation Incentive/Special Separation Bonus programs (VSI/SSB), proved to be statistically insignificant.

- Involuntary Reduction in Active Duty Policy (IRAD) was not statistically significant in any model.

- MSR2 (Having time in service between MSR and MSR+2 years) was significant for jet and prop pilots only. This indicated a significant difference in retention behavior between these two groups and all others in that they are less likely to let the "stay" decision at MSR affect a subsequent decision after MSR.

- MSR3 (Being in a career point between MSR+3 and MSR+5 (which equates to approximately 9 to 11 years of service)) was a significant factor for all groups indicating that as time increases beyond MSR+2, continuation rates increase.

- UNEMP (Civilian Unemployment) was found to be significant only in the propeller pilot model. Turner speculated that higher unemployment was coincidental with lower airline hiring, which may have been a determinant for a corresponding lower propeller pilot retention.

This analysis identified the statistical relationships between the various force structure policies and the underlying voluntary survival rate of Naval aviators. Of particular value to this thesis is the base of retention data Turner constructed. His retention data will provide the basis for the dependent variables in upcoming analyses.

D. SUMMARY

The literature makes a case for looking to economic opportunity indicators to predict changes in attrition rates. Several multiple regression approaches have been used to analyze the career decision determinants of Naval aviators. The studies by both Lawry and Kleinman examined individual attrition behavior using logistic regression models, and found the most significant explanatory variables to be those associated with opportunities for employment and other economic factors.

The studies by Cymrot and Turner suggest methodologies for determining attrition rates and using grouped data and linear multivariate regression to analyze attrition behavior, respectively.

This study borrows elements from each of these studies to try to explain and predict attrition in the form of a useful and practical tool for decision makers. The next chapter outlines the specific approaches used to investigate attrition in this study.

III. METHODOLOGY

An underlying assumption in this study is that attrition decisions are a function of two sets of factors:

- intrinsic, personal/individual factors such as job satisfaction, race, marital status, children, experiences, aversion to risk, value system etc., and
- extrinsic, environmental factors such as employment opportunity, potential earnings, state of the economy indicators and the political climate.

The former factors are important in that they establish a baseline of probabilities of attrition for the population of Naval aviators after MOS. The probability of attrition for this population is theorized to follow a logistic distribution along a symmetrical curve with diminishing probability densities at the tails. (Cymrot, 1989) This shape suggests that at the tails, members are committed to either resigning or staying in the Navy, while the center contains the undecided aviators who by default remain in the Navy unless (or until) they decide to resign. A hypothesis of this study is that, holding constant major changes in the political climate (not at war, for example), the undecided population is substantially influenced by factors which essentially reflect economic opportunity.

The central objective of this study was to develop a model useful for predicting Navy pilot attrition. To accomplish this objective, the methodology followed these basic steps:

- Gather a wide variety of potential explanatory variables.

- Correlate these variables individually with grouped cohort Naval aviator attrition rates, using a Pearson Correlation, to identify candidate variables for a multivariate regression model.
- Build multivariate regression models for each aviator group.
- Test the predictive value of the models using holdout data.

The remainder of this chapter will cover techniques used for collecting data, selecting variables, structuring the relationships and analyzing variable characteristics.

A. DATA COLLECTION

1. Attrition Data and Measures

Prior research has focused primarily on measuring the attrition behavior responses of individuals to certain characteristics or environments. This study uses aggregated data from a database created as a major thesis component (Turner, 1995). The database was created from the Officer Master File (OMF) maintained by the Defense Manpower Data Center (DMDC). Pilots under an obligation such as ACP or MOS, as well as involuntarily separated pilots, were eliminated from the data set. Cohort continuation rates of each year group and aviation community were obtained for fiscal years 1978 through 1990 from the database, and subsequently transformed into attrition rates for consistency in terminology. This was done by computing the complement of the continuation rates (1 - CR). Year groups were converted to relative years of service in each fiscal year. This attrition data is presented in the Appendix.

As mentioned in the introduction, the population of pilots under study includes those aviators between the end of their MOS and twelve years of service. An initial examination of the attrition behavior in all communities revealed distinct differences between the early YOS and later YOS aviators. First, Figure 3 illustrates how significant the average attrition rate *levels* of each aviation community were in YOS 5 to 8, compared to the attrition rates (including YOS 9 to 12) of other years in a career. As can be seen, attrition starts growing in year 5 and is at its maximum level in years 6 through 8. Attrition drops noticeably in year 9, and rates in the 9 to 12 YOS period are well below those in the preceding periods.

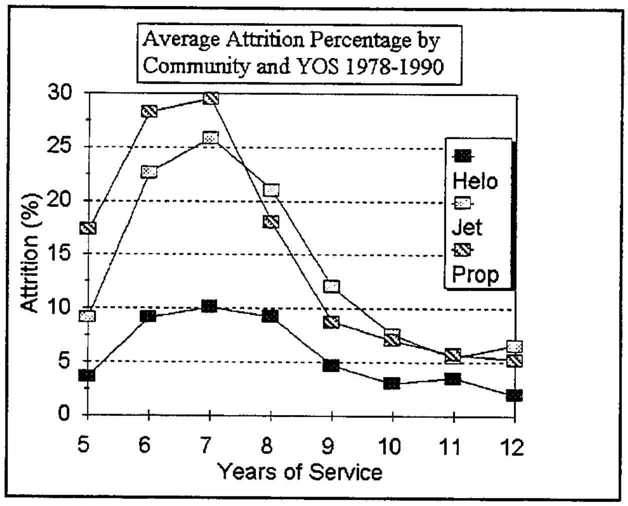

Figure 3. Average Attrition Rates by YOS.

Second, Figure 4 shows how significantly higher the *variation* in average attrition rates are for YOS 5 to 8 aviators, compared to those of aviators with YOS 9 to 12.

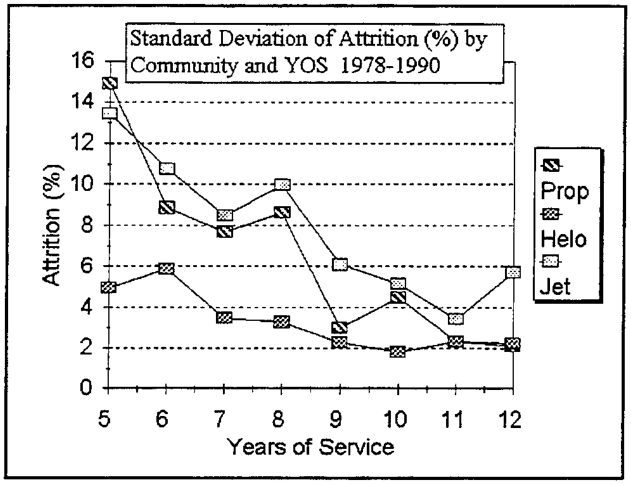

Figure 4. Standard Deviation of Attrition by YOS.

Given the distinctively different behavior of the attrition data, the populations of each community were grouped separately into two categories; one with five to eight years of service (YOS 5-8) and another with nine to twelve Years of Service (YOS 9-12). Separate attrition rates were calculated for each community subgroup.

The set of selected dependent variables were labeled as follows:

- PROP(5-8). Propeller community attrition rate for pilots with between five and eight YOS.
- PROP(9-12). Propeller community attrition rate for pilots with between eight and twelve YOS.
- HELO(5-8). Helicopter community attrition rate for pilots with between five and eight YOS.
- HELO(9-12). Helicopter community attrition rate for pilots with between eight and twelve YOS.
- JET(5-8). Jet community attrition rate for pilots with between five and eight YOS.

- JET(9-12) Jet community attrition rate for pilots with between eight and twelve YOS.

2. Explanatory Data and Measures

A wide variety of economic variables were initially considered for explaining changes in Naval aviator attrition. The literature suggested a variety of indicators including national unemployment rate and airline industry hiring rates as major factors. Other factors were considered. For example, perhaps the perception that economic conditions were changing (capturing trend) might be just as important as the actual level of unemployment or hiring rates.

One of the requirements this study placed in considering potential independent variables was that the explanatory variables be based on data readily available to decision makers. All variable data, therefore, came directly from published statistics or were mathematically derived from them. This does not presume that aviators actually track chosen economic indicators, from the Wall Street Journal for example, but that perhaps these indicators capture the prevailing perception by aviators of the future of the economy or civilian employment market, regardless of what information they actually assimilate into their stay/quit decision.

There were four basic variables to consider: a measure of unemployment, a measure of the economy as a whole, a measure of airline employment prospects and a measure of pay. For each basic variable (except for pay, due to its incremental nature), two kinds of measures were calculated: the numerical *level* for a given year, and an indication of its change or *trend*.

The change in a variable was measured by subtracting the previous year's level from the current year's level.

For measures of unemployment, this study looked at the national unemployment rate. But understanding that the target group (college educated Naval aviators) would most likely be looking for management, engineering or some other professional trade, 'Professional Unemployment' rates were also examined.

For measures of the economy as a whole, this study examined the Composite Index of Leading Economic Indicators, which includes twelve separate economic measures such as factory orders, inventories and interest rates, intended to anticipate near-future economic activity.

For measures of airline employment prospects, this study examined numbers of pilots hired by major domestic carriers.

For measures of pay, this study examined the ratio between military pay and airline pay. Military pay values were obtained from military pay scales for Naval aviators at the rank of O-3, over eight years of service and include flight pay, basic allowance for quarters (BAQ) and basic allowance for subsistence (BAS). These were compared to airline compensation survey statistics conducted by the Bureau of Labor and Statistics in 1975, 1980, 1984 and 1989. A weighted average salary was computed for each survey year, and interpolated values were inserted in the adjoining years.

The selection bases above led to an initial list of potential explanatory variables. Variable labels and their hypothesized effects on attrition are listed below:

- UNEMP. National Unemployment rate (t_0)[3], measured in terms of percent of unemployment. The study hypothesized this variable to negatively affect attrition rates, based on the expectation that as job opportunities diminish, fear of the job market would cause attrition rates to diminish.

- dUNEMP. Change in National Unemployment, measured in terms of percent change in unemployment or UNEMP$(t_0\text{-}t_{-1})$. The study hypothesized this variable to negatively affect attrition rates, based on the expectation that if unemployment was increasing over the period, fear of a continuation of the trend would cause attrition rates to diminish.

- PR\UN. Professional ("white collar") Unemployment rate[1], measured in terms of percent of unemployment among professionals. The study hypothesized this variable to negatively affect attrition rates, based on the expectation that as professional job opportunities diminish, fear of the job market would cause attrition rates to diminish.

- dPR\UN. Change in Professional Unemployment, measured in terms of percent change in professional unemployment or PR\UN$(t_0\text{-}t_{-1})$. The study hypothesized this variable to negatively affect attrition rates, based on the expectation that if professional unemployment was increasing over the period, fear of a continuation of the trend would cause attrition rates to diminish.

- CILEI. Composite Index of (twelve) Leading Economic Indicators year average[4], measured on its own point scale. The study hypothesized this variable to positively affect attrition rates, based on the expectation that positive economic forecasts would be a comforting signal for life in the civilian sector, and lead to an increase in attrition rates.

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[3]Department of Labor, Bureau of Labor and Statistics, Employment and Earnings, 1976-1992.

[4] U.S. Department of Commerce, Bureau of Economic Analysis, 1988-1992, Business Conditions Digest, 1978-1987.

- dCILEI. Change in Composite Index of (twelve) Leading Economic Indicators, measured in terms of change in points or $CI(t_0 - t_{-1})$. The study hypothesized this variable to positively affect attrition rates, based on the expectation that if the index was increasing over the period, a continuation of the trend would be expected, leading to optimism about the civilian sector economy and a subsequent increase in attrition rates.

- HIRES. Airline Hires[5], measured in terms of number of pilots hired by major domestic carriers. The study hypothesized that major domestic carriers represented the most significant competing industry for pilots and had a positive effect on attrition, based on the expectation that if airlines were actively hiring, pilots would have a higher probability of getting hired and pilot attrition rates would increase.

- dHIRES. Change in Airline Hires, measured in terms of difference in the number of pilots hired or $HIRES(t_0 - t_{-1})$. The study hypothesized this variable to positively affect attrition rates, based on the expectation that with a trend of increasing airline hiring over the period, a continuation of the trend would be perceived, leading to optimism in the probability of airline employment and cause attrition rates to increase.

- MP/AP. Military Pay to Airline Pay ratio. Prior studies hypothesized this variable to have a negative effect on attrition, based on the expectation that if military pay increases as percentage of Airline pay, attrition rates would decrease. This author, however, expects no effect from this variable, based on reasons articulated in chapter 2.

B. STRUCTURING RELATIONSHIPS: TIME LAG

The collected economic data are based on the calendar year, while the retention data are based on the fiscal year. The statistical analyses relates a given fiscal year's attrition rate (dependent variable) to the preceding calendar year's economic condition (independent variables). By structuring the relationship in this way, the attrition is essentially lagged nine

[5] Source: Future Airline Professionals of America.

months from the hypothesized economic determinants. This structuring is both practical and sensible.

If economic environmental factors influence decisions to resign, when are these effects observed and acted upon towards a decision? To resign, Naval officers must submit a written request six months in advance. Some studies have consequently used a six-month lag when comparing independent variables to attrition. The approach of this study assumes that it is unlikely that an individual, comforted by positive economic news one day, immediately submits a resignation letter the next day. More likely is that the undecided aviator (or perhaps likely-to-resign aviator in waiting) continuously monitors the economic environment. After a period of examining encouraging economic trends and/or convinced of a high probability of employment, he becomes comfortable enough to resign and subsequently chooses a date to submit his resignation letter. In short, the lag between favorable economic news and actual attrition must be *at least* six months, and is probably more than six months by a period which varies across individuals.

This rationale led to the chosen structure of a nine month lag to compare economic and attrition data. Making this assumption not only makes sense, but removes problematic calculations converting calender year economic data to fit the fiscal year retention records.

C. INITIAL ANALYSIS OF VARIABLES

As a preliminary step in the analysis, attrition rates for all groups were plotted for fiscal years 1978-1990 (Figures 5 and 6). When some of the variables were examined, certain characteristics emerged that helped identify potential explanatory variables. For example, jet and propeller attrition rates were very similar to each other and higher than helicopter attrition rates. Particularly revealing was that the changes in attrition rates from year to year tended to be relatively smoothly shaped, particularly for the YOS(5-8) group (see Fig.5). This characteristic made an excellent case for considering the previous year's attrition rate as an important predictor for the current year's attrition rate. To capture this, the previous year's attrition rates were added to the set of *independent* variables. These attrition rate independent variables were labeled RATE(-1) for the corresponding group.

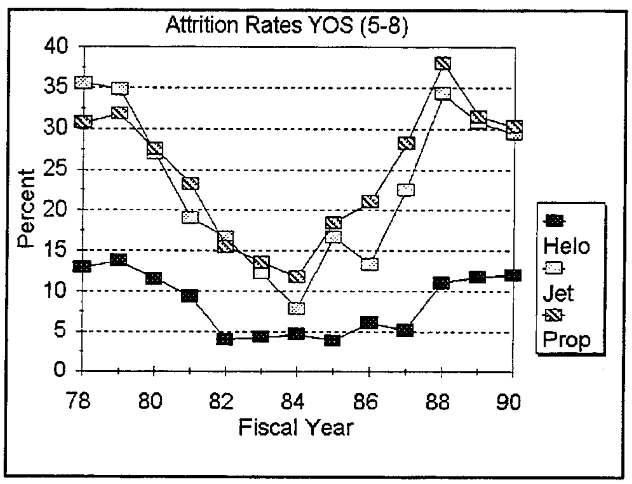

Figure 5. Attrition Rates, 1978-1990.

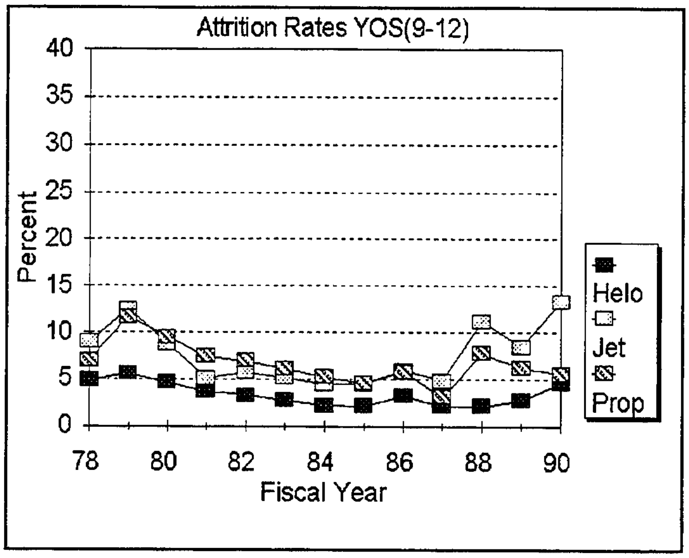

Figure 6. Attrition rates, 1978-1990.

As a second preliminary step, attrition rates were plotted against airline hiring levels (Figures 7 and 8) for each community. The clear similarity of curve shapes for some of the pilot groups suggested a stronger relationship than the correlation coefficient might indicate (due to the sum of the differences between the corresponding points). The relationship seen in Figure 5 between PROP(5-8), JET(5-8) and airline hires suggests that during upturns in hiring rates, attrition rates respond one year later, while downturns in hiring are met with a quick response in reduced attrition. This pattern suggest that a relationship may exist between attrition and the airline hiring rate, but the lag that should be used, contemporaneous or one year lag, is unclear. Attrition seems to show some relationship to HIRES at both times $t_{(0)}$ and $t_{(-1)}$. To reflect both of these time points, a new variable averaging HIRES at both $t_{(0)}$ and $t_{(-1)}$ was constructed and added to the list of potential variables, labeled 'HIRE2'.

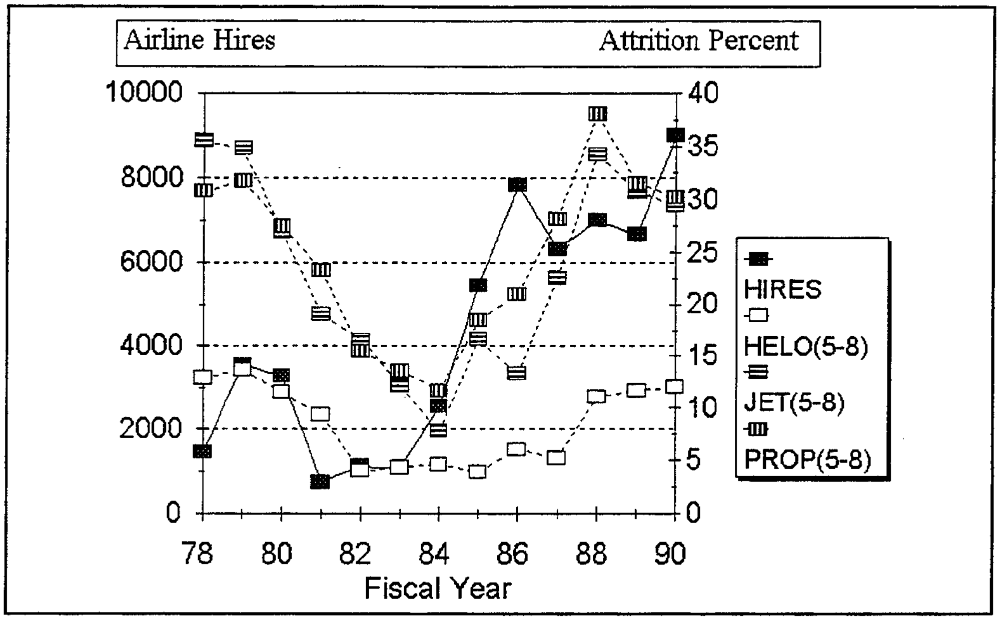

Figure 7. Airline Hires vs. Attrition Rates.

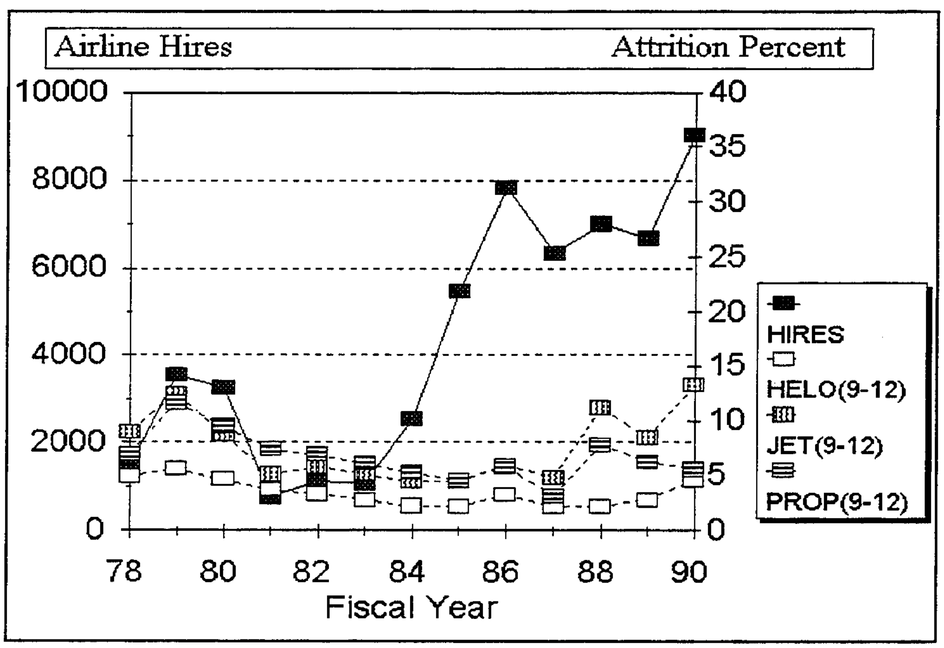

Figure 8. Airline Hires vs. Attrition Rates.

D. SUMMARY

This chapter outlines the methodology of gathering data, the measures used, classifying and characterizing the data and addressing time period issues.

At this point, we have a list of eleven potential independent variables to be analyzed for their effects on one dependent variable, attrition, in six different community subgroups. The independent variables are: UNEMP (national unemployment rate), dUNEMP (change in national unemployment rate), PR\UN (professional unemployment rate), dPR\UN (change in professional unemployment rate), CILEI (composite index of leading economic indicators), dCILEI (change in composite index of leading economic indicators), HIRES (major airline hires), dHIRES (change in major airline hires), HIRE2 (average of major airline hires, current and previous), MP/AP (military pay to airline pay ratio) and RATE(-1) (corresponding attrition rate from the previous year).

The next chapter will introduce the methodology for evaluating and selecting these potential variables as predictors of attrition. Correlation analysis will be used to trim the list to a smaller set of variables to be examined in regression models. Then, candidate regression models incorporating various combinations of variables will be developed. Finally, the various regression models will be validated by testing their predictive ability.

IV. STATISTICAL ANALYSIS

A. ORGANIZATION

Chapter three discussed the processes by which a wide variety of potential economic indicator variables were chosen in an attempt to reflect an array of economic factors. In this chapter, the statistical analysis starts by performing Pearson Correlation tests on the variables to gain insight into the strength of relationships between the independent variables and pilot attrition, and to examine correlation between pairs of independent variables which may signal problems with collinearity. Next, experiments are performed fitting various OLS regression models to the data, to observe model and variable behavior. A later section presents statistic results and the candidate model selection process. Finally, the selected models undergo a validation process to test their effectiveness as predictive models.

B. CORRELATION RESULTS

1. Independent Variables and Attrition

To gain insight into the strength of relationship between various potential independent variables and the dependent attrition variables, Pearson Correlations were performed using the Minitab (ver. 10) statistical software package. The results in Table 4.1 are expressions of ***r*** values.

	Helo(5-8)	Jet (5-8)	Prop(5-8)	Helo(9-12)	Jet(9-12)	Prop(9-12)
UNEMP	**-.762**	**-.813**	**-.857**	**-.468**	**-.740**	**-.360**
dUNEMP	-.227	-.405	-.402	-.010	-.302	-.014
PR\UN	-.167	-.235	-.467	.273	-.277	.294
dPR\UN	-.077	.001	.018	.040	-.042	-.056
CILEI	.093	.236	.438	-.404	.310	-.438
dCILEI	-.222	-.026	-.065	-.313	-.063	-.285
HIRES	.168	.257	.475	-.185	.394	-.299
dHIRES	-.007	-.003	-.074	.131	.313	.035
MP/AP	-.284	-.185	.007	-.620	-.020	.348
HIRE2	.184	.279	.536	-.240	.332	-.334
RATE(-1)	**.719**	**.614**	**.667**	**.765**	**.703**	**.500**

Table 4.1 Correlation values between dependent and independent variables.

Correlation values were examined using three criteria; magnitude, direction and consistency. The expected strongest relationships between independent and dependent variables were those with high ***r*** values, a direction of sign consistent with economic sense, and consistent direction of signs among the dependent variables. While ***r*** value of .3 is a common rule of thumb minimum threshold for significance, values as low as .275 were considered as possibly significant (to include as many variables as possible).

Three levels of correlation strength of relationships between independent and dependent variables emerged from the analysis; "strong" (in bold in Table 4.1) meeting all of the criteria, "marginal" meeting some of the criteria, and "weak" which failed all criteria. The strongest of the explanatory variables was UNEMP (national unemployment) which had the highest and most consistent (negative) correlation with attrition in all six of the groups.

Almost as strong was the RATE(-1) variable which showed a pattern of relatively strong positive correlation in all six groups. Marginal explanatory variables, which met the significance threshold and/or had sign consistency in at least three out of six groups, were found to be: dUNEMP (change in national unemployment) which showed a consistently negative correlation to all dependent variables but low magnitude in two populations; PR\UN (professional unemployment), CILEI (composite index of leading economic indicators), HIRES (airline hires), and HIRE2 (airline hires, 2 year average). Weak explanatory variables were found to be: dPR\UN (change in professional unemployment) which showed near-zero values of correlation; dCILEI (change in the composite index of leading economic indicators), which also had low values and a sign direction which implies that as economic indicators worsen, attrition increases; dHIRES (change in airline hires), which had low correlation values in all but one group; and MP/AP (military pay to airline pay ratio), which had a strong correlation only for the HELO(9-12) group, the group seemingly least likely to react to that explanatory variable.

2. Correlation Between Independent Variables

The correlation analysis also examined the degree of correlation between independent variables, which impacts the subsequent regression analysis. The correlation values are presented in Table 4.2. The RATE(-1) variables are specified and abbreviated (e.g., the RATE(-1) variable corresponding to the HELO(5-8) group is labeled RH5(-1)) for presentation in this table.

	UNEMP	dUNMP	PR\UN	dPR\UN	CILEI	dCILEI	HIRES	dHIRES	HIRE2	MP/AP
dUNMP	**.465**									
PR\UN	**.602**	**.562**								
dPR\UN	-.007	.658	.300							
CILEI	**-.453**	**-.435**	**-.904**	-.147						
dCILEI	.191	-.574	-.167	-.682	.250					
HIRES	**-.564**	**-.508**	**-.919**	-.144	**.918**	.122				
dHIRES	-.045	-.613	-.228	-.485	.244	.436	.401			
HIRE2	**-.597**	-.179	**-.925**	-.009	**.919**	.000	**.961**	.132		
MP/AP	-.027	-.005	-.486	.118	.738	.170	.544	.186	.533	
RH5(-1)	-.242	.016	-.002	.074	-.185	-.424	-.116	-.242	-.053	-.278
RJ5(-1)	-.179	.072	-.162	.103	.043	-.514	.111	-.179	.174	-.130
RP5(-1)	-.282	.003	**-.397**	.147	.305	-.419	.296	-.282	**.406**	.088
RH9(-1)	**-.400**	**.351**	**.399**	.160	**-.618**	-.484	**-.487**	-.400	**-.406**	-.687
RJ9(-1)	**-.338**	.113	-.192	.042	.012	-.564	.056	-.338	.162	-.156
RP9(-1)	**-.500**	**.414**	.226	.183	**-.434**	-.602	**-.395**	-.500	-.276	-.359

Table 4.2 Correlation Values Between Independent Variables

High correlation values were found between many of the potential explanatory variables. Independent variables labeled previously as strong or marginal explainers of attrition are underlined and in bold in Table 4.2. Significant pairwise correlations (***r*** > .3) between these strong and marginal explanatory variables are in bold in Table 4.2. The results show that high correlation exists between almost every strong and marginal explanatory variable except for the RATE(-1) variable in the YOS (5-8) groups. These results also signal that collinearity problems may arise using combinations of these variables in linear regression models.

In OLS regression, it is assumed that no linear relationship exists among the independent variables. When correlation between two explanatory variables is stronger than the correlation between an explanatory variable and the dependent variable, multi-collinearity exists. Ordinarily this is the result of the double counting of a causal relationship, and results in misspecification of the regression model.

> Multi collinearity is common and even inevitable in much of the data in fields like sociology, economics, and business. This is true because in these fields it is not generally possible to choose values for the independent variables; one must use the data available. In economics, as an example, data are virtually notorious for multi collinearity. (Wesolowsky, 1976, pg.49)

C. MODEL EXPERIMENTATION AND DEVELOPMENT

In the process of selecting/evaluating the appropriate OLS regression model, several characteristics were desired:

- The model should be practical in use. Decision makers should not have to perform unusual calculations or research numerous or obscure statistical reports to effectively use the model to predict attrition.
- Variable behavior (the direction of the relationship with the dependent variable) should be consistent with economic "common sense".
- The model should have a high explanatory ability (high R^2).
- The model should have low multi-collinearity.

Based on the findings of the correlation analyses, a number of regression models were constructed and fit to the data. Experimental regressions were performed using various combinations of the strong and marginal variables yielding interesting results. Table 4.3 displays the typical finding from these experimental regressions and illustrates the problems in dealing with multi collinearity in linear regression models. The table shows what happened to regression R^2 and t-ratios, in the JET(5-8) group, as independent variables were added (in decreasing order from the strongest individual univariate correlation strength).

	1 VAR	2 VAR	3 VAR	4 VAR	5 VAR	6 VAR
R^2	.660	.664	.729	.767	.870	.897
UNEMP	-4.62	-2.92	-3.27	-3.44	-4.82	-2.49
RATE(-1)		.26	-.33	-.20	-.61	.43
HIRE2			-1.48	-1.71	-1.02	.09
CILEI				1.15	2.29	2.00
PR\UN					2.35	2.72
dUNEMP						-1.27

Table 4.3 R^2 and T-Ratios of Variable Coefficients in Models for JET(5-8).

Though the signs of the relationships to the JET(5-8) attrition variable were as expected in the earlier univariate correlations, these signs changed for many of the variables here in the regressions, and signs were inconsistent from model to model. For example, PR\UN should negatively effect attrition (as indicated by its univariate correlation and economic sense), but in the regression, the t-ratios are positive. Another example: the RATE(-1) variable which had strong positive univariate correlation, showed low t-ratios and inconsistent signs in the various regression models.

Similar results were found in the other pilot groups. Perhaps this was due to the fact that the magnitude of correlation between the independent variables and the dependent (attrition) variables was relatively low (particularly in the case of aviators with YOS (9-12)), compared to the magnitude of correlation between the explanatory variables.

The findings from these initial regression analyses were that no model simultaneously fulfilled all characteristics expressed earlier as desirable. Therefore, model candidates were developed based on tradeoffs in selection criteria.

Three candidate models were developed using the following approaches:

- A univariate model (omitting all other variables except UNEMP) met the criteria for simplicity, consistency and low collinearity, but also had low explanatory power and large standard error.

- A simple bivariate model using UNEMP and RATE(-1) maintained simplicity, consistency and low collinearity, but provided a better fit (higher $R^{2)}$ and a lower standard error.

- A multivariate model, using five selected variables while omitting variables which were intuitively redundant or did not make economic sense was also considered. This model sacrificed low multi collinearity and consistency for a better fit (higher R^2). The selected variables were those that showed the strongest pattern of correlation while omitting redundant variables (e.g., HIRE2 in lieu of both HIRES and HIRE2).

The relationships between the selected independent variables to pilot attrition rates were specified by the following candidate multivariate regression models:

Model 1; $AR_i = \alpha_0 + \beta_1\text{UNEMP}_i + \in$

Model 2; $AR_i = \alpha_0 + \beta_1\text{UNEMP}_i + \beta_2\text{RATE(-1)}_I + \in$

Model 3; $AR_i = \alpha_0 + \beta_1\text{UNEMP}_I + \beta_2\text{dUNEMP}_i + \beta_3\text{CILEI}_i + \beta_4\text{HIRE2}_i + \beta_5\text{RATE(-1)}_I + \in$

were AR is the attrition rate for group i, α is the intercept term, the β terms are the coefficients of the selected variables in the equation to be estimated and ϵ represents the error term. Separate OLS models were estimated for the six pilot populations.

D. CANDIDATE MODEL STATISTICAL RESULTS

The OLS results are summarized in Tables 4.4 through 4.9 below.

	Model 1		Model 2		Model 3	
Variable	**Coeff.**	**T-ratio**	**Coeff.**	**T-ratio**	**Coeff.**	**T-ratio**
Constant	22.872	8.81	14.832	6.05	29.419	11.02
UNEMP	-2.149	-3.90	-1.434	-2.05	-3.553	-1.741
dUNEMP					.785	.66
CILEI					.05307	.55
HIRE2					-.00115	-1.05
RATE(-1)			.394	1.53	-.11194	-.20
R^2	.580		.660		.718	

Table 4.4 Helicopter Pilots with 5 to 8 YOS.

	Model 1		Model 2		Model 3	
Variable	**Coeff.**	**T-ratio**	**Coeff.**	**T-ratio**	**Coeff.**	**T-ratio**
Constant	60.945	10.55	56.328	9.353	59.784	10.06
UNEMP	-5.665	-4.623	-5.254	-2.91	-8.764	-2.41
dUNEMP					.9058	.32
CILEI					.2430	1.11
HIRE2					-.0034	-1.57
RATE(-1)			.0844	.324	-.1365	-.35
R^2	.660		.664		.771	

Table 4.5 Jet Pilots with 5 to 8 YOS.

	Model 1		Model 2		Model 3	
Variable	**Coeff.**	**T-ratio**	**Coeff.**	**T-ratio**	**Coeff.**	**T-ratio**
Constant	59.037	13.46	61.012	13.28	58.687	11.13
UNEMP	-5.132	-5.51	-5.3018	-3.30	-6.637	-1.67
dUNEMP					1.184	.39
CILEI					.1184	.52
HIRE2					-.0009	-.44
RATE(-1)			-.0353	-.13	-.190	-.38
R^2	.734		.734		.746	

Table 4.6 Propeller Pilots with 5 to 8 YOS.

	Model 1		Model 2		Model 3	
Variable	Coeff.	T-ratio	Coeff.	T-ratio	Coeff.	T-ratio
Constant	6.125	5.58	.765	.92	10.217	12.38
UNEMP	-.409	-1.76	.067	.282	-.412	-.65
dUNEMP					-.0567	-.16
CILEI					-.032	-1.07
HIRE2					.000	.07
RATE(-1)			.262	2.99	.109	.637
R^2	.219		.588		.719	

Table 4.7 Helo Pilots with 9 to 12 YOS.

	Model 1		Model 2		Model 3	
Variable	Coeff.	T-ratio	Coeff.	T-ratio	Coeff.	T-ratio
Constant	19.063	8.59	12.416	5.77	1.466	.62
UNEMP	-1.716	-3.64	-1.124	-1.75	-1.155	-.81
dUNEMP					-.192	-.17
CILEI					.085	.99
HIRE2					-.001	-.89
RATE(-1)			.122	1.31	.148	.98
R^2	.546		.613		.681	

Table 4.8 Jet Pilots with 9 to 12 YOS.

	Model 1		Model 2		Model 3	
Variable	**Coeff.**	**T-ratio**	**Coeff.**	**T-ratio**	**Coeff.**	**T-ratio**
Constant	10.524	4.97	2.008	.98	10.205	7.30
UNEMP	-.576	-1.28	.158	.22	.563	.54
dUNEMP					-1.147	-1.46
CILEI					-.090	-1.52
HIRE2					.000	.235
RATE(-1)			.152	1.28	.267	.13
R^2	.130		.253		.759	

Table 4.9 Propeller Pilots with 9 to 12 YOS.

In all six pilot populations, better fits (higher R^2) were found in models as the number of variables increased. A higher R^2, however, does not necessarily translate to better predictive performance. The next section tests the predictive ability of the candidate models.

E. MODEL VALIDATION

Cross checks of the candidate models were performed to evaluate their validity. To do this, hold-out data was omitted for each year (1978 through 1990) while regression model parameters were estimated on the remaining data. The resulting estimated models were then applied to the hold-out data to predict attrition rates for each hold-out year. The process was repeated throughout the data set. The predicted attrition rates for each year were compared to actual attrition rates, and errors (in terms of percent of actual attrition rate) were calculated. The error mean, the error median, the standard deviation of errors, minimum error and maximum error were evaluated. Tables 4.10 through 4.12 contain the error statistics from predictions based on the three regression models.

Group	Mean	Median	Std. Dev.	Max. Err	Min. Err
HELO(5-8)	2.258	2.358	**1.494**	**4.592**	.014
PROP(5-8)	**4.956**	**3.965**	**3.400**	**12.983**	.917
JET(5-8)	**3.750**	**3.691**	**2.614**	**9.935**	.210
HELO(9-12)	.971	.892	.620	2.012	.143
JET(9-12)	2.278	2.330	.882	3.558	.870
PROP(9-12)	1.738	1.474	1.413	5.007	**.023**

Table 4.10 Attrition Rate Error Statistics from Regression Model 1.

Group	Mean	Median	Std. Dev.	Max. Err	Min. Err
HELO(5-8)	2.149	2.054	1.551	4.745	.038
PROP(5-8)	5.313	4.473	3.626	14.337	**.325**
JET(5-8)	4.157	3.841	2.928	9.947	.101
HELO(9-12)	**.787**	**.551**	.445	**1.547**	.149
JET(9-12)	**2.252**	**2.210**	**.824**	**3.498**	.858
PROP(9-12)	1.632	**.651**	1.525	4.746	.095

Table 4.11 Attrition Rate Error Statistics from Regression Model 2.

Group	Mean	Median	Std.Dev.	Max. Err	Min. Err
HELO(5-8)	2.679	1.957	2.554	7.295	**0.013**
PROP(5-8)	7.243	5.772	3.792	13.573	2.792
JET(5-8)	5.935	4.751	4.121	13.060	**0.009**
HELO(9-12)	1.058	1.023	**.369**	2.091	.647
JET(9-12)	2.776	2.966	1.528	6.334	.284
PROP(9-12)	**1.525**	1.657	**.925**	**2.956**	.218

Table 4.12 Attrition Rate Error Statistics from Regression Model 3.

Additionally, prediction errors from the models were compared to a "naive prediction". This was done to see if the regression predictions could outperform a simple naive approach, which was defined as last year's attrition. In other words, if a prediction were based simply on one equal to the previous year's attrition rate for each pilot group, how would this compare to the candidate regression model predictions? Table 4.13 contains analogous error statistics for the naive predictions. Numbers in bold represent the winning (lowest error) measure between all four models.

Group	Mean	Median	Std. Dev.	Max. Err	Min. Err
HELO(5-8)	**1.991**	**0.878**	1.937	5.865	.304
PROP(5-8)	6.480	4.401	4.931	18.433	.723
JET(5-8)	5.347	4.276	3.865	14.131	1.019
HELO(9-12)	.861	.682	.698	2.574	**.000**
JET(9-12)	2.650	2.757	2.045	6.384	**.005**
PROP(9-12)	1.954	1.575	1.434	4.703	0.481

Table 4.13 Attrition Rate Error Statistics Using Naive Predictions.

Ultimately, the goal of this procedure was to find the model which made the best prediction. "Best" may be defined differently, depending upon the user. Some users may want a model which yields the lowest maximum error, while others may prefer the lowest median or mean error. Regardless of criteria preference, some models were clear winners over others. Model 1 had the most (11 out of 30) lowest errors, followed by Model 2 (with 9 out of 30). Model 3 and the naive approach produced less winners (6 and 4 respectively).

Some pilot group attrition rates were clearly predicted better by some models over others. Model 1 best predicted attrition rates for the JET(5-8) and PROP(5-8) groups. Model 2 best predicted attrition rates for the HELO(9-12) and JET(9-12) groups. The best model for predicting attrition rates for the PROP(9-12) group could be argued between Model 2 or Model 3. The best model for predicting attrition rates for the HELO(5-8) group is also unclear, with Model 1 having the lowest standard deviation of error and lowest maximum error, while the naive approach had a lower mean and median of error.

It should be noted that even though certain regression models could outperform the naive approach for the three pilot populations with nine to twelve years of service, the improvement was marginal. The same could be said about the HELO(5-8) group, where variation in attrition rates is relatively low. However, in the two populations which experience the highest levels and variation in attrition rates, the simple univariate model predicted rates with significantly less error than the naive approach.

Further discussion of these results, conclusions and recommendations are presented in the next chapter.

V. CONCLUSIONS AND RECOMMENDATIONS

This thesis investigated the ability to predict naval aviator attrition using linear regression models with economic data as predictors. It examined economic and attrition data from 1978 to 1990. The analysis found that in most groups, simple regression models outperformed naive predictions based on the prevailing retention rates. The results did not provide conclusive findings about the economic environmental determinants of pilot attrition.

A. SUMMARY OF FINDINGS

1. Predictive Model Performance

Three regression models were constructed. Individual models proved to be effective in predicting attrition for five out of the six pilot groups. The findings of model performance are summarized below:

- No single model is best for all groups
- Attrition rates for YOS(5-8) and YOS(9-12) groups are substantially different, and the models that best predict attrition for these two different YOS periods are also different. Model 1 tends to be best for YOS(5-8), (except for HELO). Model 2 tends to be best for YOS(9-12).
- A simple, univariate regression model (Model 1), using the national unemployment rate as a predictor, was the most effective of the models tested in predicting attrition rates for jet and propeller pilots with five to eight years of service.
- A simple, 2-variable regression model(Model 2), using the national unemployment rate and the previous year's attrition rate as predictors, was the most effective of the models tested in predicting attrition rates for helicopter and jet pilots with nine to twelve years of service.

- A multi variate regression model (Model 3), using the national unemployment rate, change in the rate, composite index of leading economic indicators, airline hiring rate (2 year average) and previous year's attrition rate as predictors, could be argued to be effective in predicting the attrition rate for only the propeller pilots with nine to twelve years of service, but was overall the least effective of the three models.

- Significant improvement over a naive prediction is achieved only for the PROP(5-8) and JET(5-8) groups. Fortunately, these are the groups where you would expect and hope for the best results because: (1) attrition is highest and most variable in the YOS(5-8) period and thus a predictive model is most useful here, and, (2) propeller and jet groups are most likely to respond to what is happening in the commercial market place.

2. Explanatory Variables

A high degree of multicollinearity in the multiple regressions prevented meaningful evaluations and tests of significance of many of the explanatory variables. Extracting causal determinants of attrition using the methodology of this study proved ineffective, given that many of the economic variables changed in consort. Still, this investigation revealed a degree of understanding into the effects of these economic variables on aviator attrition. These limited findings are listed below:

- The national unemployment rate, as hypothesized, negatively affected attrition rates. This variable was the strongest and most consistent predictor of pilot attrition in almost every regression model.

- Change in national unemployment, as hypothesized, negatively affected attrition rates. This was the only "trend" variable which showed any significance as a predictor.

- The professional unemployment rate, as hypothesized, negatively affected attrition rates, but to a lesser degree than national unemployment. Perhaps this is due to the fact that this statistic is not well publicized.

- Change in professional unemployment did not demonstrate an effect on attrition rates.

- The Composite Index of (twelve) Leading Economic Indicators had an inconclusive effect on attrition rates.

- Change in Composite Index of (twelve) Leading Economic Indicators did not demonstrate an effect on attrition rates. A very low, but consistently negative correlation was found which was contrary to its hypothesized effects.

- Airline hiring rates had an inconclusive effect on attrition rates. This finding contradicted the hypothesized effects, the observations in other studies and the personal experience-based perceptions of this researcher. This finding may indicate weaknesses in the study.

- Changes in airline hiring did not demonstrate an effect on attrition rates.

- Military pay to airline pay ratio did not demonstrate an effect on attrition rates, which was an expected result.

- Previous attrition rates were found to be significant predictor variables.

B. METHODOLOGY EVALUATION

One of the assumptions of this study was that when cohort pilot attrition rates are aggregated, individual attrition determinants are averaged out, and the populations are somewhat homogeneous from year to year. This may not be the case, and could explain why evaluating individual predictors was difficult. For example, if for one or two years there were great employment opportunities for engineers, and those inclined to seek that line of work responded by resigning, then the population in the following year has changed (depleted of engineers) and the new population may not respond to similar signals of opportunity. The same might be said for other professions (including the airline industry) which may attract naval aviators.

Given that economic measures used as variables are notorious for collinearity, then perhaps linear regression is not the best approach for predicting attrition. Perhaps a more sophisticated approach which starts with the prevailing attrition rate and then applies a vector based on combined economic and policy measures would perform better than the models developed in this study.

The methodology used in this study to capture the proper time lag between economic events and attrition rate responses is rather crude. Additionally, other significant economic measures may exist which were not addressed in this study.

Despite the potential weaknesses in the approach of this study, effective predictive models still emerged. This may indicate that economic environmental factors, as hypothesized in Chapter I, are largely responsible for the changes in attrition and could be better understood with further study.

C. RECOMMENDATIONS

Future research could continue by adding more recent data to the file, which will enable the models to be further refined. Data sources could be developed to allow analysis of pilot attrition on a monthly basis, to refine and develop models, and to study the effects of different time lags between independent and dependent variables.

A critical manpower function is to monitor and correctly interpret trends in naval aviator retention. This analysis helps provide manpower planners with a force-shaping tool for predicting the size of tomorrow's aviation community.

APPENDIX. DATA

AGGREGATED COHORT AVIATOR ATTRITION RATE DATA						
FY	HELO(5-8)	JET(5-8)	PROP(5-8)	HELO(9-12)	JET(9-12)	PROP(9-12
1978	12.92	35.53	30.76	4.90	8.98	6.95
1979	13.75	34.81	31.78	5.58	12.47	11.65
1980	11.55	26.92	27.50	4.64	8.76	9.52
1981	9.36	19.03	23.23	3.70	5.05	7.39
1982	4.01	16.62	15.47	3.28	5.75	6.90
1983	4.33	12.22	13.58	2.74	5.11	6.07
1984	4.64	7.82	11.69	2.20	4.48	5.24
1985	3.89	16.67	18.45	2.14	4.47	4.54
1986	6.08	13.29	21.04	3.21	5.90	5.81
1987	5.20	22.52	28.19	2.17	4.79	3.10
1988	11.06	34.32	38.10	2.17	11.18	7.80
1989	11.70	30.73	31.53	2.75	8.42	6.22
1990	12.01	29.46	30.22	4.57	13.31	5.54

Source: (Turner, 1995)

ECONOMIC VARIABLE DATA

Cal. Year	UNEMP	dUNEMP	PR\UN	dPR\UN	CILEI	dCILEI	HIRES	HIRE2	dHIRES	MILPAY	ALPAY	MP/AP	FY
1977	6.6	-0.7	4.3	-0.3	136.4	11.7	1446	996.5	899	1966	4100	0.48	1978
1978	5.6	-1	3.5	-0.8	141.8	5.4	3550	2498	2104	2060	4491	0.46	1979
1979	5.5	-0.1	3.3	-0.2	140.1	-1.7	3271	3410.5	-279	2187	4883	0.45	1980
1980	6.9	1.4	3.7	0.4	131.2	-8.9	750	2010.5	-2521	2484	5275	0.47	1981
1981	7.3	0.4	4	0.3	140.9	9.7	1116	933	366	2888	5527	0.52	1982
1982	9.3	2	4.9	0.9	136.9	-4.1	1050	1083	-66	2988	5780	0.52	1983
1983	9.2	-0.1	3.3	-1.6	156.0	19.2	2552	1801	1502	3092	6033	0.51	1984
1984	7.1	-2.1	2.6	-0.7	165.7	9.7	5465	4008.5	2913	3182	6286	0.51	1985
1985	6.8	-0.3	2.4	-0.2	169.1	3.3	7840	6652.5	2375	3270	6406	0.51	1986
1986	6.6	-0.2	2.4	0	179.3	10.2	6341	7090.5	-1499	3349	6526	0.51	1987
1987	5.8	-0.8	2.3	-0.1	189.4	10.2	7010	6675.5	669	3409	6647	0.51	1988
1988	5.2	-0.6	1.9	-0.4	192.5	3.0	6683	6846.5	-327	3785	6768	0.56	1989
1989	5.0	-0.2	2	0.1	194.5	2.0	9026	7854.5	2343	3894	6887	0.57	1990

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